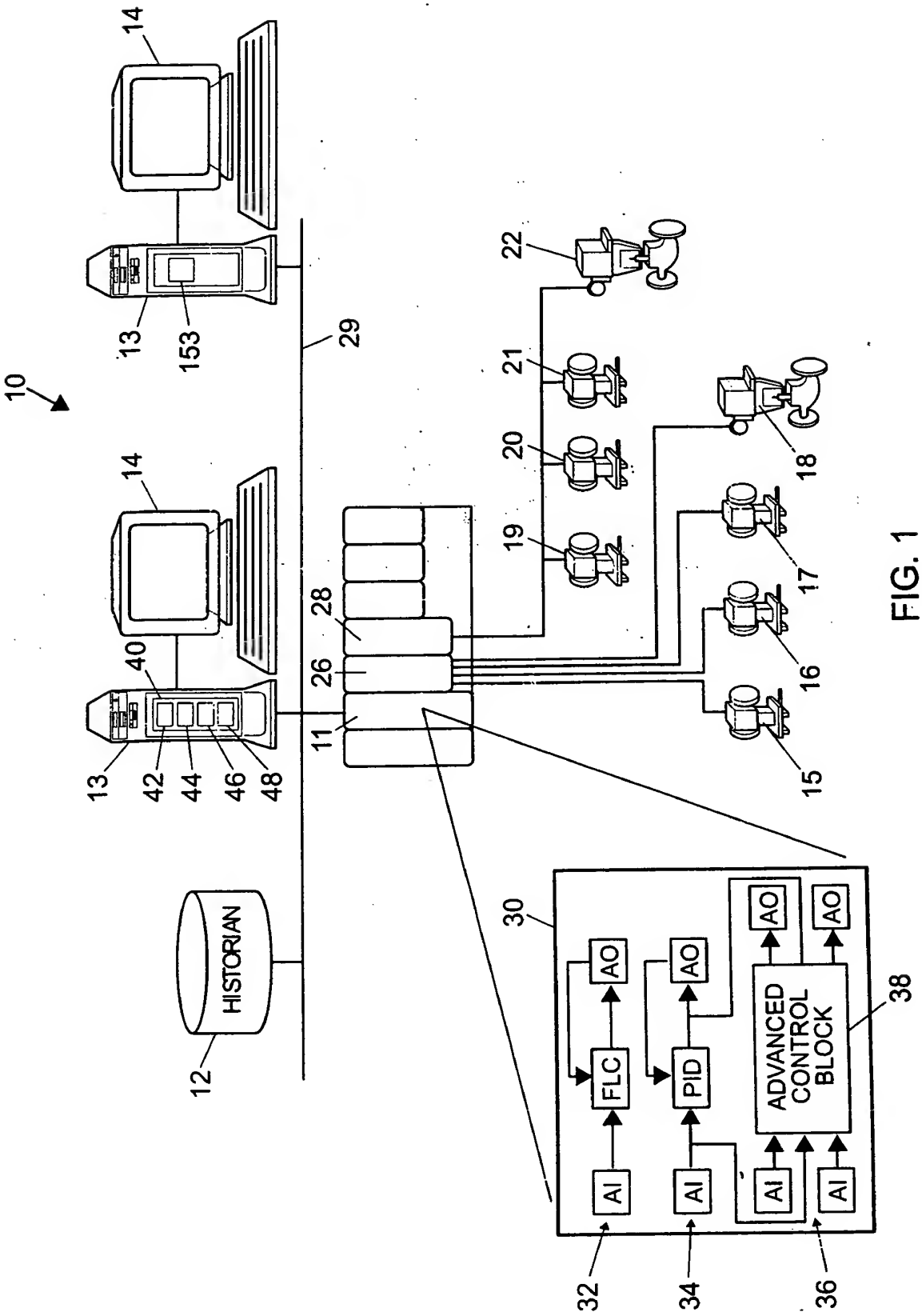
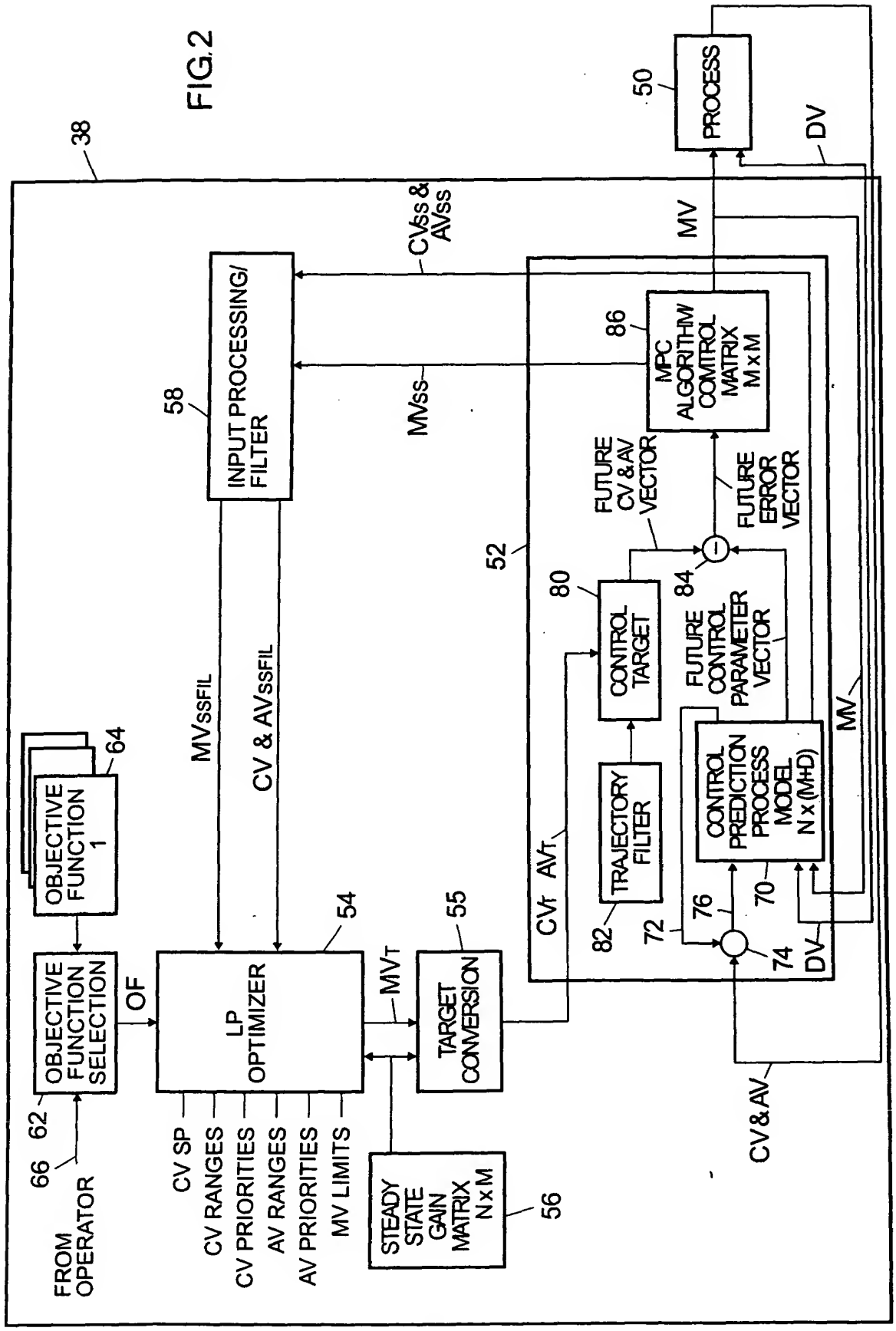

10
14
13
153
29
22
21
20
19
18
17
16
15
28
26
11
40
42
44
46
48
HISTORIAN
12
30
AO
FLC
PID
ADVANCED CONTROL BLOCK
38
AI
32
34
36

FIG. 1

FIG.2


38
50
PROCESS
DV
MV
CVss & AVss
58
INPUT PROCESSING/ FILTER
MVss
86
MPC ALGORITHM/ CONTROL MATRIX M x M
FUTURE CV & AV VECTOR
FUTURE ERROR VECTOR
52
80
CONTROL TARGET
84
FUTURE CONTROL PARAMETER VECTOR
MVSSFIL
CV & AVSSFIL
64
OBJECTIVE FUNCTION 1
CVt AVt
TRAJECTORY FILTER
82
CONTROL PREDICTION PROCESS MODEL N x (M+D)
72
76
70
74
DV
MV
54
55
OBJECTIVE FUNCTION SELECTION
OF
LP OPTIMIZER
MVT
TARGET CONVERSION
62
66
FROM OPERATOR
CV SP
CV RANGES
CV PRIORITIES
AV RANGES
AV PRIORITIES
MV LIMITS
STEADY STATE GAIN MATRIX N x M
56
CV & AV

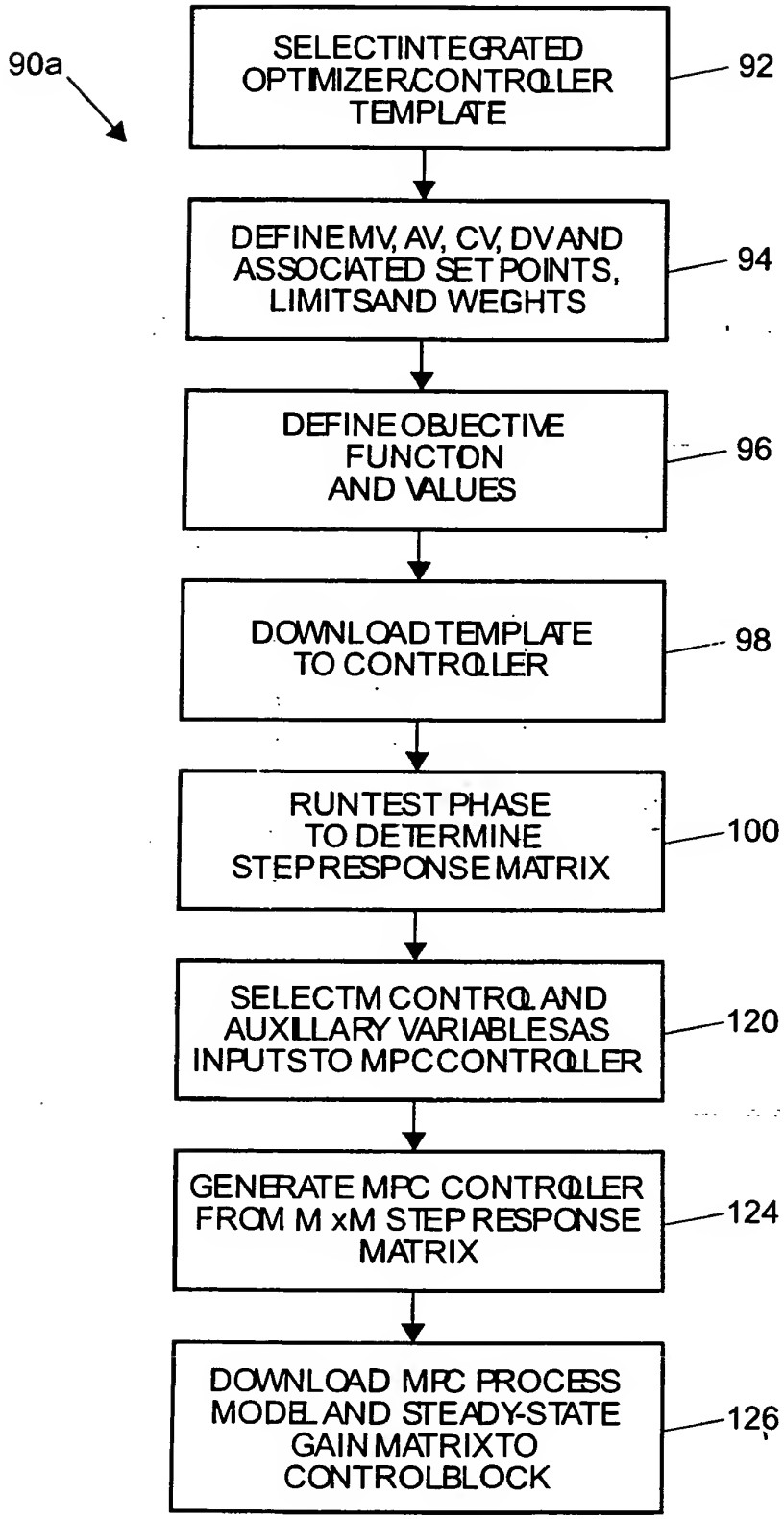

90a
SELECT INTEGRATED OPTIMIZER/CONTROLLER TEMPLATE
92
DEFINE MV, AV, CV, DV AND ASSOCIATED SET POINTS, LIMITS AND WEIGHTS
94
DEFINE OBJECTIVE FUNCTION AND VALUES
96
DOWNLOAD TEMPLATE TO CONTROLLER
98
RUN TEST PHASE TO DETERMINE STEP RESPONSE MATRIX
100
SELECT M CONTROL AND AUXILLARY VARIABLES AS INPUTS TO MPC CONTROLLER
120
GENERATE MPC CONTROLLER FROM M xM STEP RESPONSE MATRIX
124
DOWNLOAD MPC PROCESS MODEL AND STEADY-STATE GAIN MATRIX TO CONTROL BLOCK
126

FIG. 3

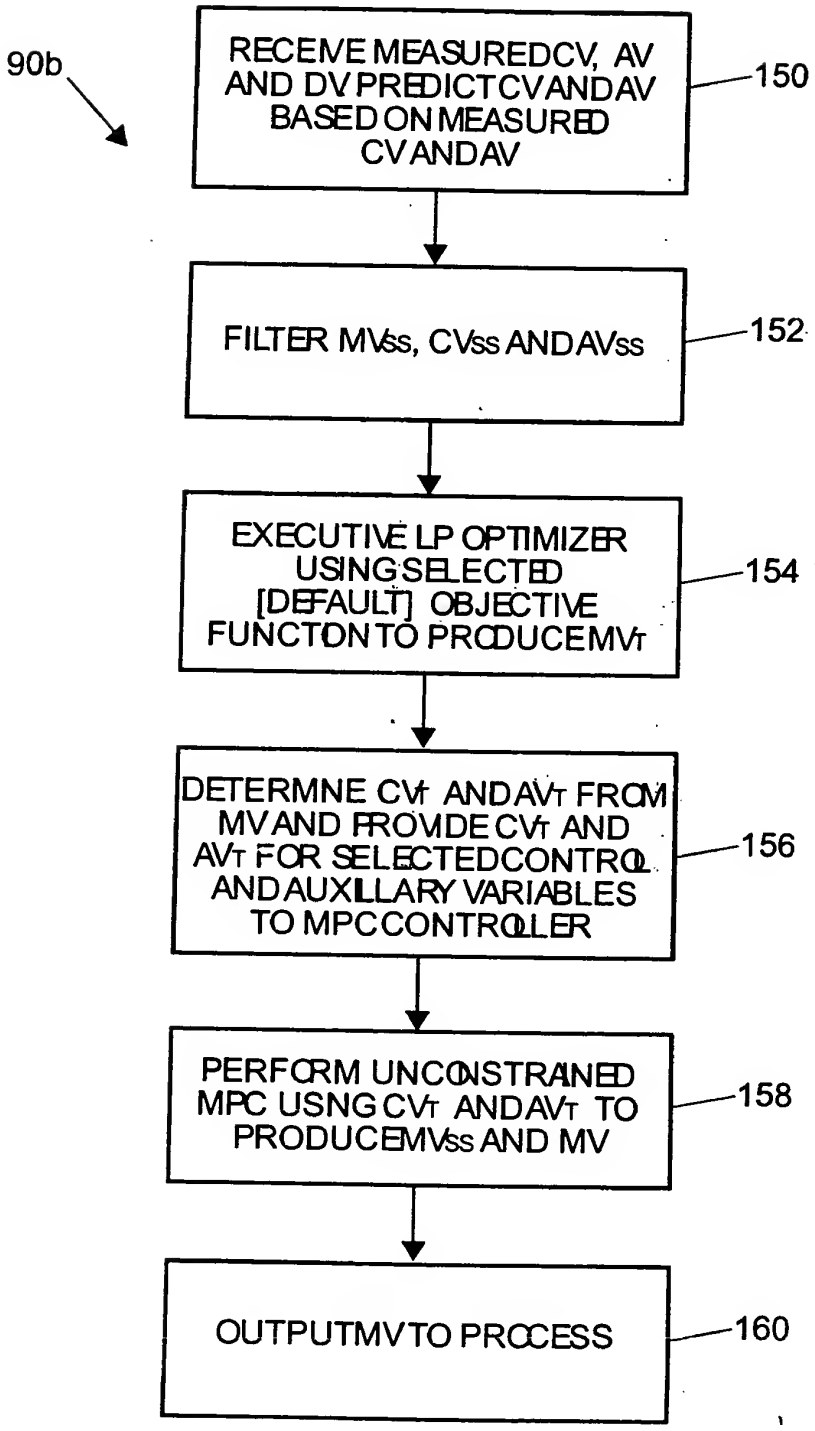

90b
RECEIVE MEASURED CV, AV AND DV PREDICT CV AND AV BASED ON MEASURED CV AND AV
150
FILTER MVss, CVss AND AVss
152
EXECUTIVE LP OPTIMIZER USING SELECTED [DEFAULT] OBJECTIVE FUNCTION TO PRODUCE MVt
154
DETERMINE CVt AND AVt FROM MV AND PROVIDE CVt AND AVt FOR SELECTED CONTROL AND AUXILLARY VARIABLES TO MPC CONTROLLER
156
PERFORM UNCONSTRAINED MPC USING CVt AND AVt TO PRODUCE MVss AND MV
158
OUTPUT MV TO PROCESS
160

FIG. 4

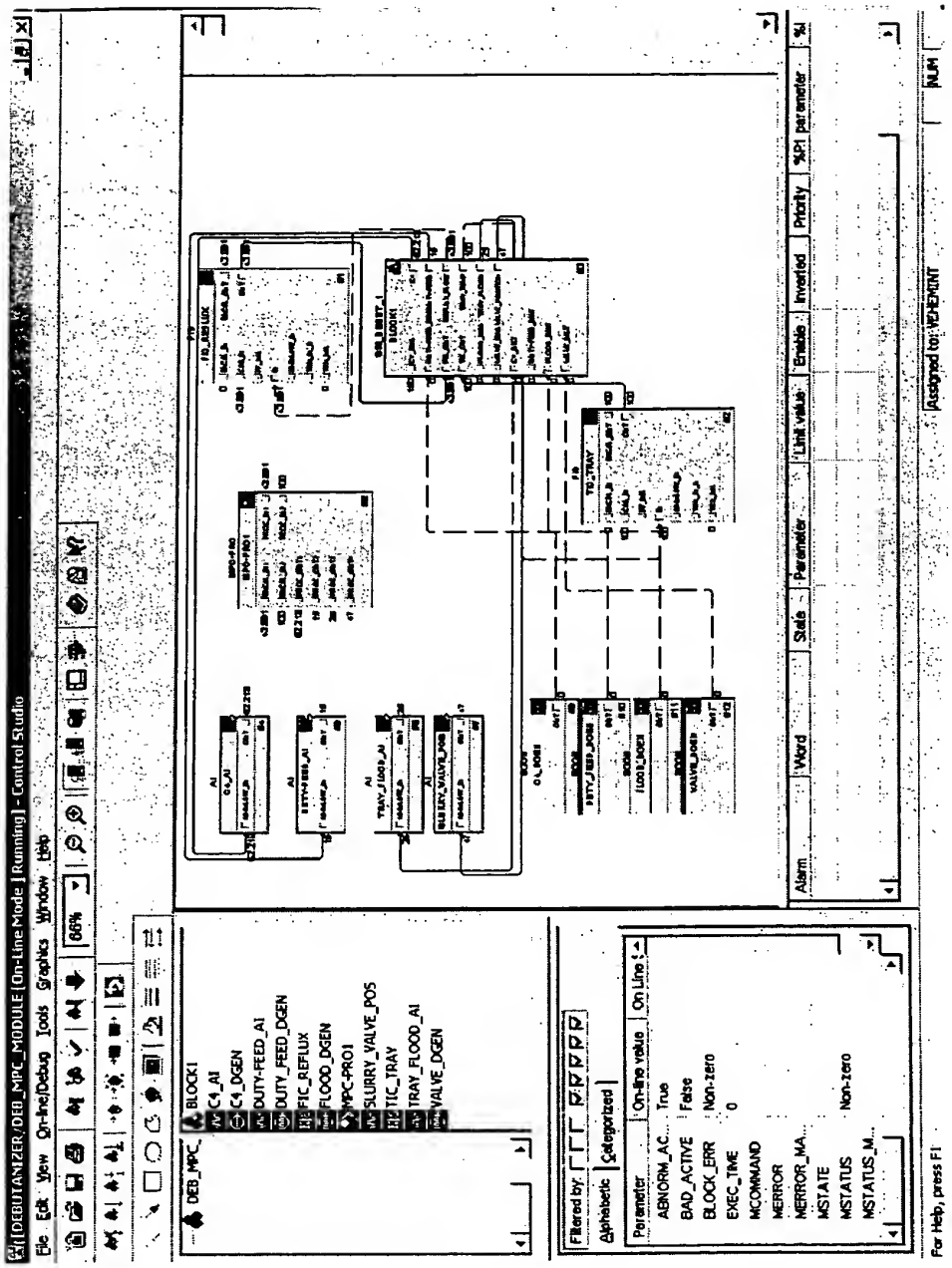

[DEBUTANIZER:/DEB_MPC_MODULE] [On-Line Mode] [Running] - Control Studio
File Edit View On-line/Debug Tools Graphics Window Help
66%
DEB_MPC
BLOCK1
C4_AI
C4_DGEN
DUTY-FEED_AI
DUTY_FEED_DGEN
FIC_REFLUX
FLOOD_DGEN
MPC-PRO1
SLURRY_VALVE_POS
TIC_TRAY
TRAY_FLOOD_AI
VALVE_DGEN
Filtered by:
Alphabetic
Categorized
Parameter
On-line value
On Line
ABNORM_AC...
True
BAD_ACTIVE
False
BLOCK_ERR
Non-zero
EXEC_TIME
0
NCOMMAND
NERROR
NERROR_MA...
NSTATE
NSTATUS
Non-zero
NSTATUS_M...
Alarm
Word
State
Parameter
Link value
Enable
Inverted
Priority
%PI parameter
Assigned to: WEHEMONT
For Help, press F1
NUM

FIG. 5

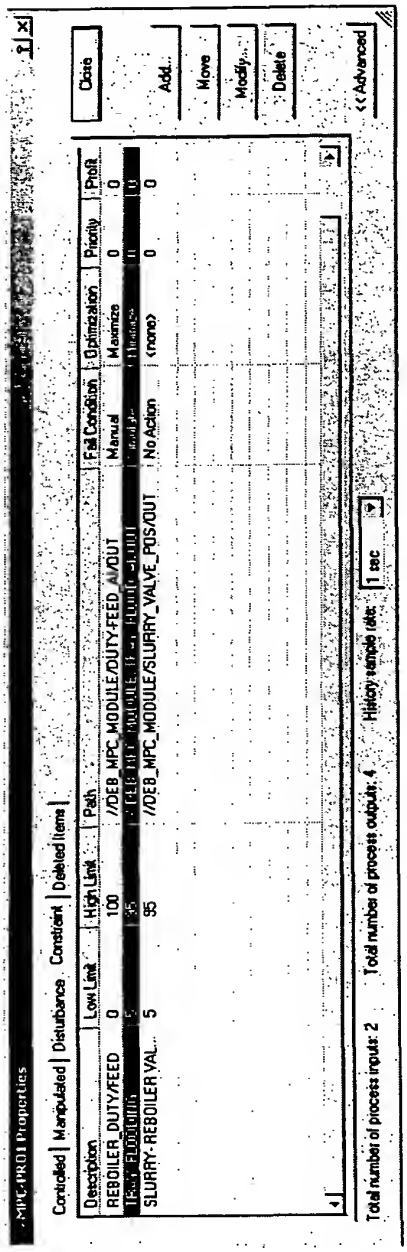

MPC_PRO1 Properties
Controlled
Manipulated
Disturbance
Constraint
Deleted Items
Description
Low Limit
High Limit
Path
Fail Condition
Optimization
Priority
Profit
REBOILER_DUTY/FEED
0
100
//DEB_MPC_MODULE/DUTY-FEED_AI/OUT
Manual
Maximize
0
0
SLURRY-REBOILER VAL...
5
95
//DEB_MPC_MODULE/SLURRY_VALVE_POS/OUT
No Action
<none>
0
0
Close
Add...
Move
Modify...
Delete
<<Advanced
Total number of process inputs: 2
Total number of process outputs: 4
History sample rate:
1 sec

FIG. 6

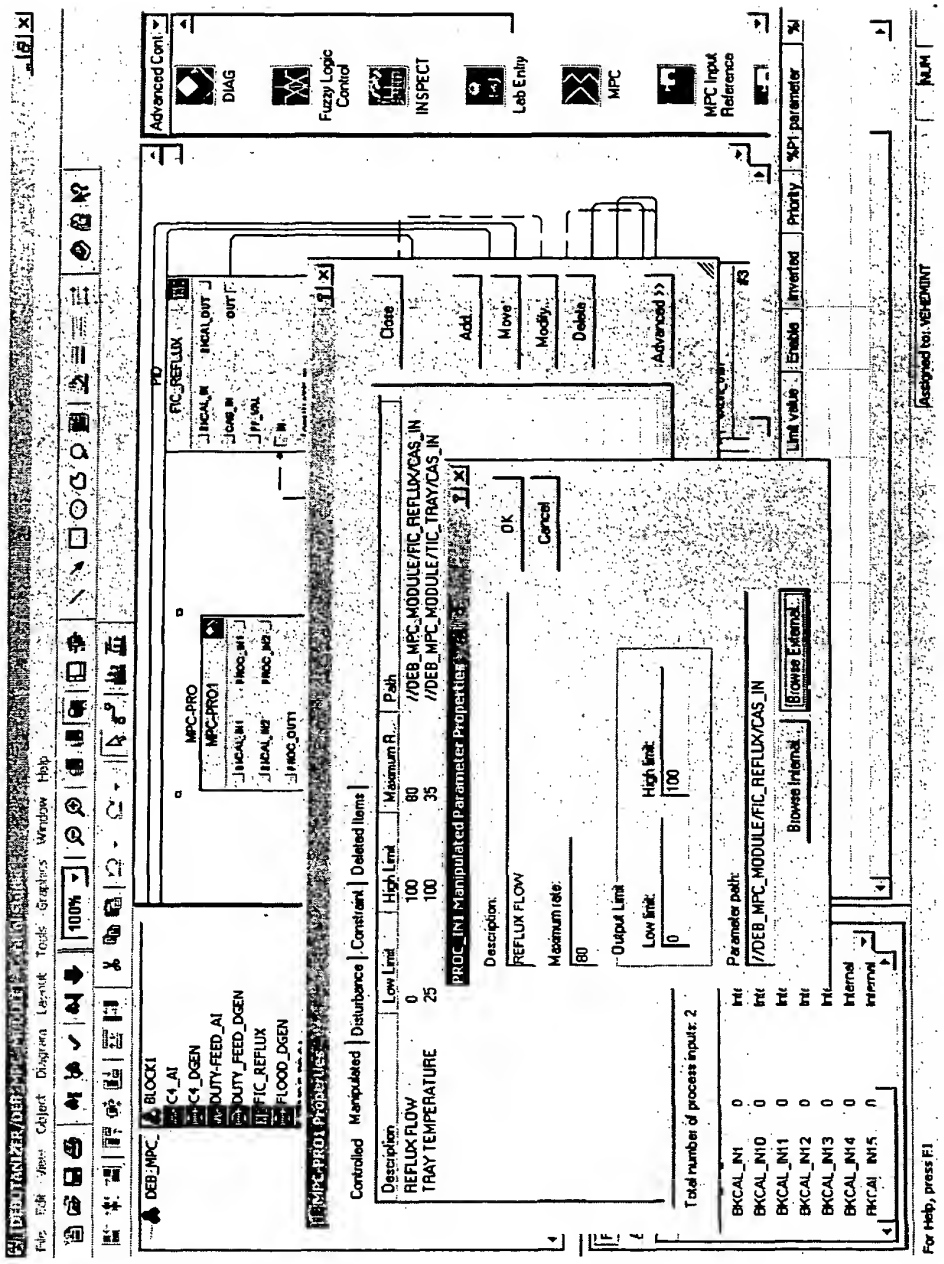

DEB_MPC
BLOCK1
C1_AI
C4_DGEN
DUTY-FEED_AI
DUTY_FEED_DGEN
FIC_REFLUX
FLOOD_DGEN
MPC-PRO1 Properties
Controlled
Manipulated
Disturbance
Constraint
Deleted Items
Description
Low Limit
High Limit
Maximum R...
Path
REFLUX FLOW
TRAY TEMPERATURE
/DEB_MPC_MODULE/FIC_REFLUX/CAS_IN
/DEB_MPC_MODULE/TIC_TRAY/CAS_IN
PROC_IN1 Manipulated Parameter Properties
Description:
REFLUX FLOW
Maximum rate:
80
Output Limit
Low limit:
High limit:
Total number of process inputs: 2
Parameter path:
Browse Internal...
Browse External...
OK
Cancel
Close
Add...
Move
Modify...
Delete
Advanced >>
MPC-PRO
MPC-PRO1
FIC_REFLUX
PID
Advanced Cont
DIAG
Fuzzy Logic Control
INSPECT
Lab Entity
MPC
MPC Input Reference
Limit value
Enable
Inverted
Priority
%P1 parameter
Assigned to: VEHEMINT
For Help, press F1

FIG. 7

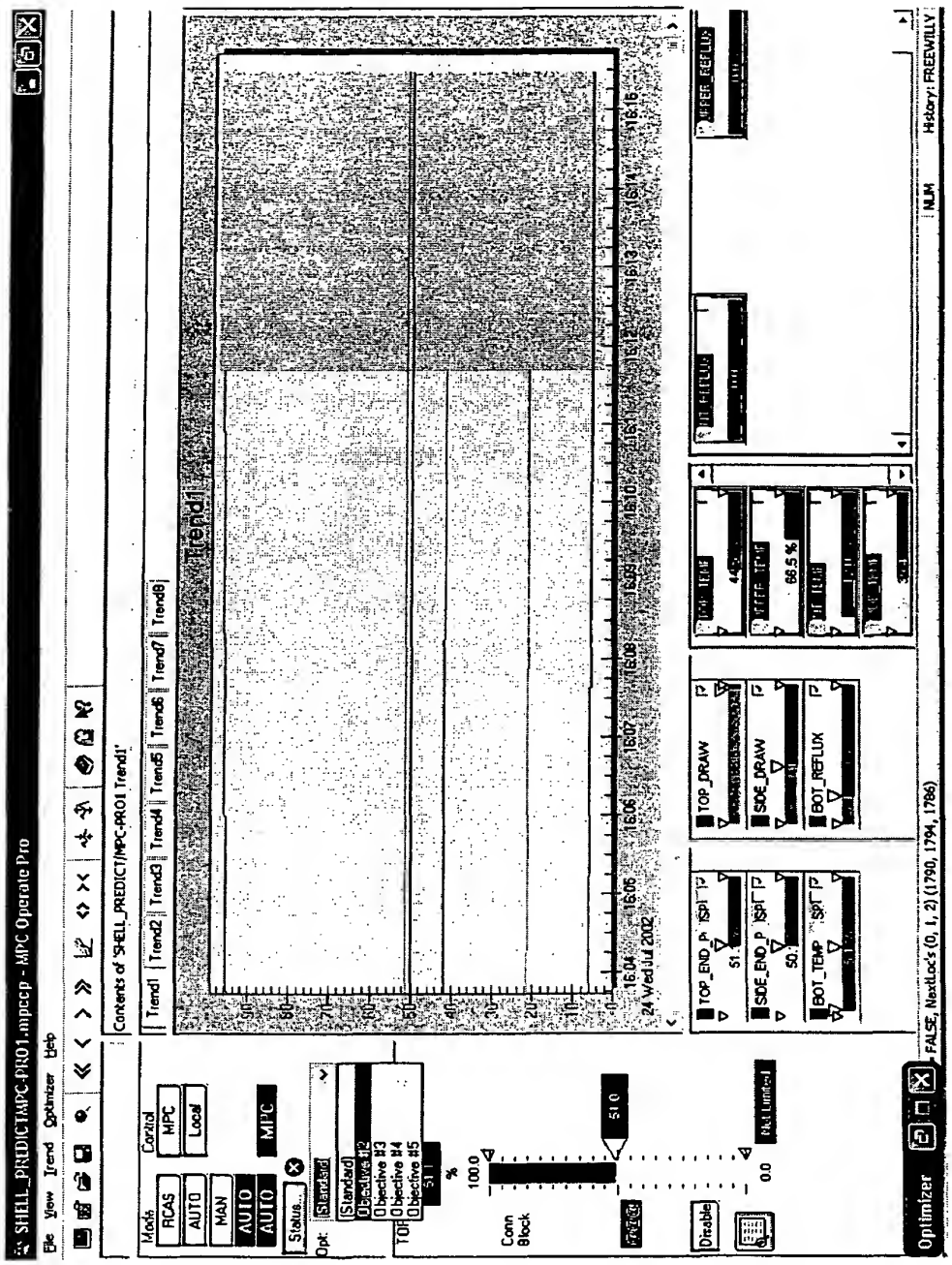

SHELL_PREDICT.MPC_PRO1.mpcep - MPC Operate Pro
File View Trend Optimizer Help
Contents of 'SHELL_PREDICT/MPC-PRO1 Trend1'
Trend1
Trend2
Trend3
Trend4
Trend5
Trend6
Trend7
Trend8
Trend1
Mode
RCAS
AUTO
MAN
AUTO
AUTO
Control
MPC
Local
MPC
Status...
Opt:
Standard
Standard
Objective #2
Objective #3
Objective #4
Objective #5
TOP_DRAW
SIDE_DRAW
BOT_REFLUX
TOP_END_P
SIDE_END_P
BOT_TEMP
Conn
Block
Disable
Optimizer
FALSE, NextLock's (0, 1, 2) (1790, 1794, 1786)
NUM
History: FREEWILLY

FIG. 8

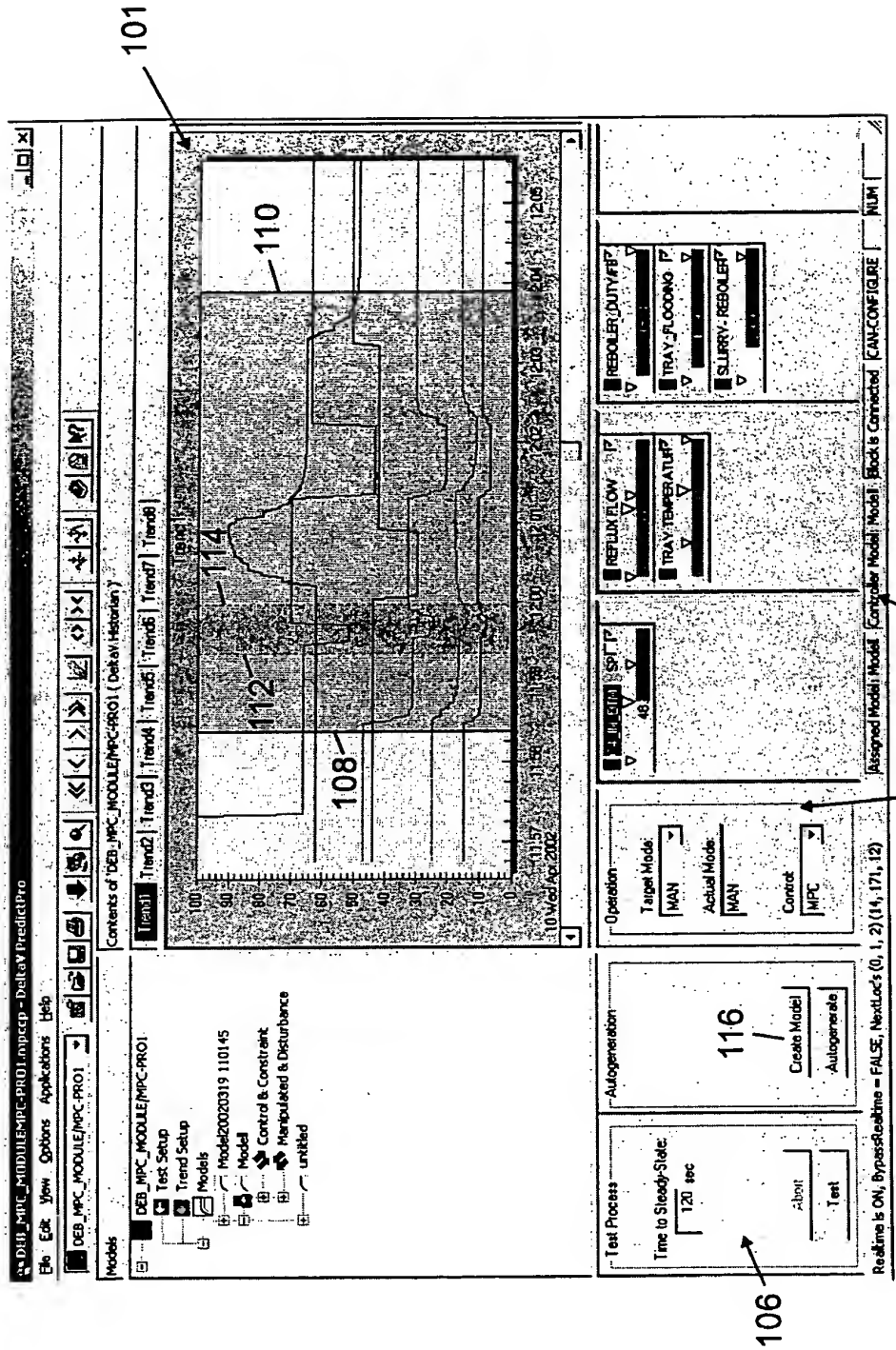

101
102
104
106
108
110
112
114
116
Assigned Model: Model
Controller Model: Model
Block is Connected
CAN-CONFIGURE
NUM
Test Process
Time to Steady-State:
120 sec
Abort
Test
Autogeneration
Create Model
Autogenerate
Operation
Target Mode:
MAN
Actual Mode:
MAN
Control
MPC
REFLUX FLOW
TRAY TEMPERATURE
REBOILER DUTY
TRAY FLOODING
SLURRY - REBOILER
Realtime is ON, BypassRealtime = FALSE, NextLoc's (0, 1, 2) (14, 171, 12)

FIG. 9

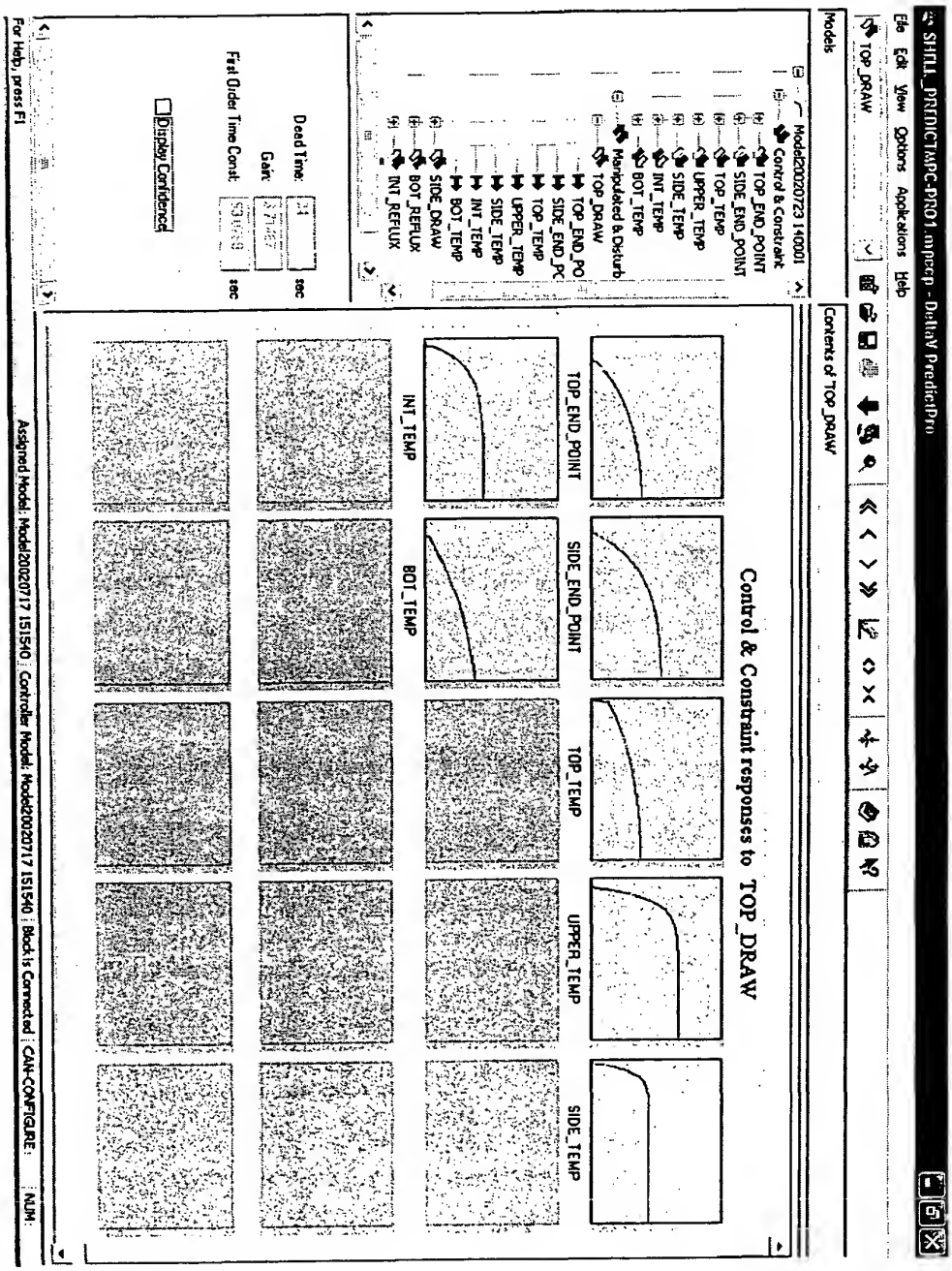

SHELL_PREDICTMPC-PRO1.mpccp - DeltaV PredictPro
File Edit View Options Applications Help
TOP_DRAW
Models
Contents of TOP_DRAW
Control & Constraint responses to TOP_DRAW
TOP_END_POINT
SIDE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Dead Time:
Gain:
First Order Time Const:
sec
Display Confidence
For Help, press F1
Assigned Model: Model20020717 151540 Controller Model: Model20020717 151540 Block is Connected CAN-CONFIGURE NUM

FIG. 10

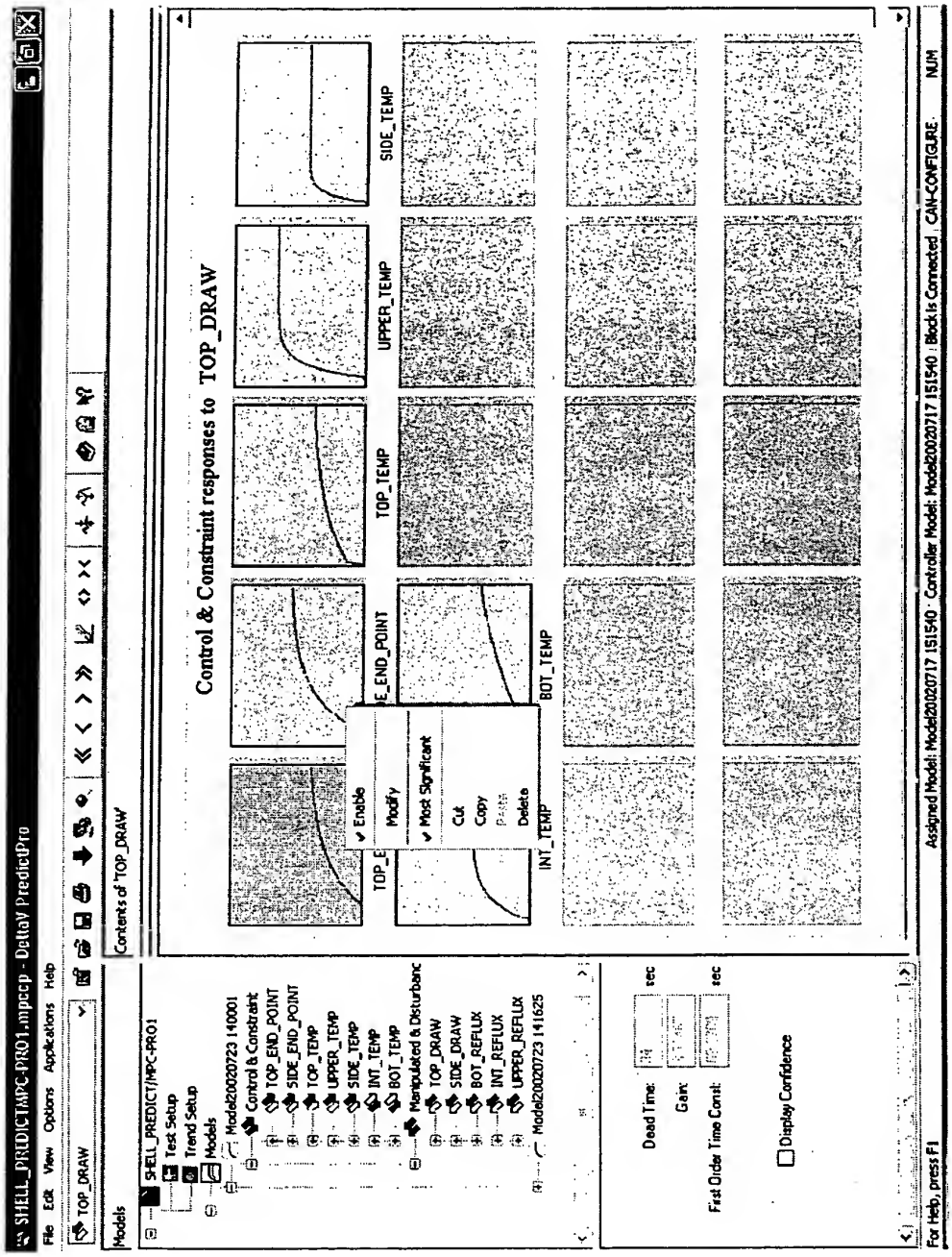

SHELL_PREDICTMPC-PRO1.mpccp - DeltaV PredictPro
File Edit View Options Applications Help
TOP_DRAW
Models
Contents of 'TOP_DRAW'
SHELL_PREDICT/MPC-PRO1
Test Setup
Trend Setup
Models
Model20020723 140001
Control & Constraint
TOP_END_POINT
SIDE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Manipulated & Disturbanc
TOP_DRAW
SIDE_DRAW
BOT_REFLUX
INT_REFLUX
UPPER_REFLUX
Model20020723 141625
Control & Constraint responses to TOP_DRAW
Enable
Modify
Most Significant
Cut
Copy
Paste
Delete
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Dead Time:
sec
Gain:
First Order Time Const:
sec
Display Confidence
For Help, press F1
Assigned Model: Model20020717 151540 : Controller Model: Model20020717 151540 : Block Is Connected
CAN-CONFIGURE
NUM

FIG. 11

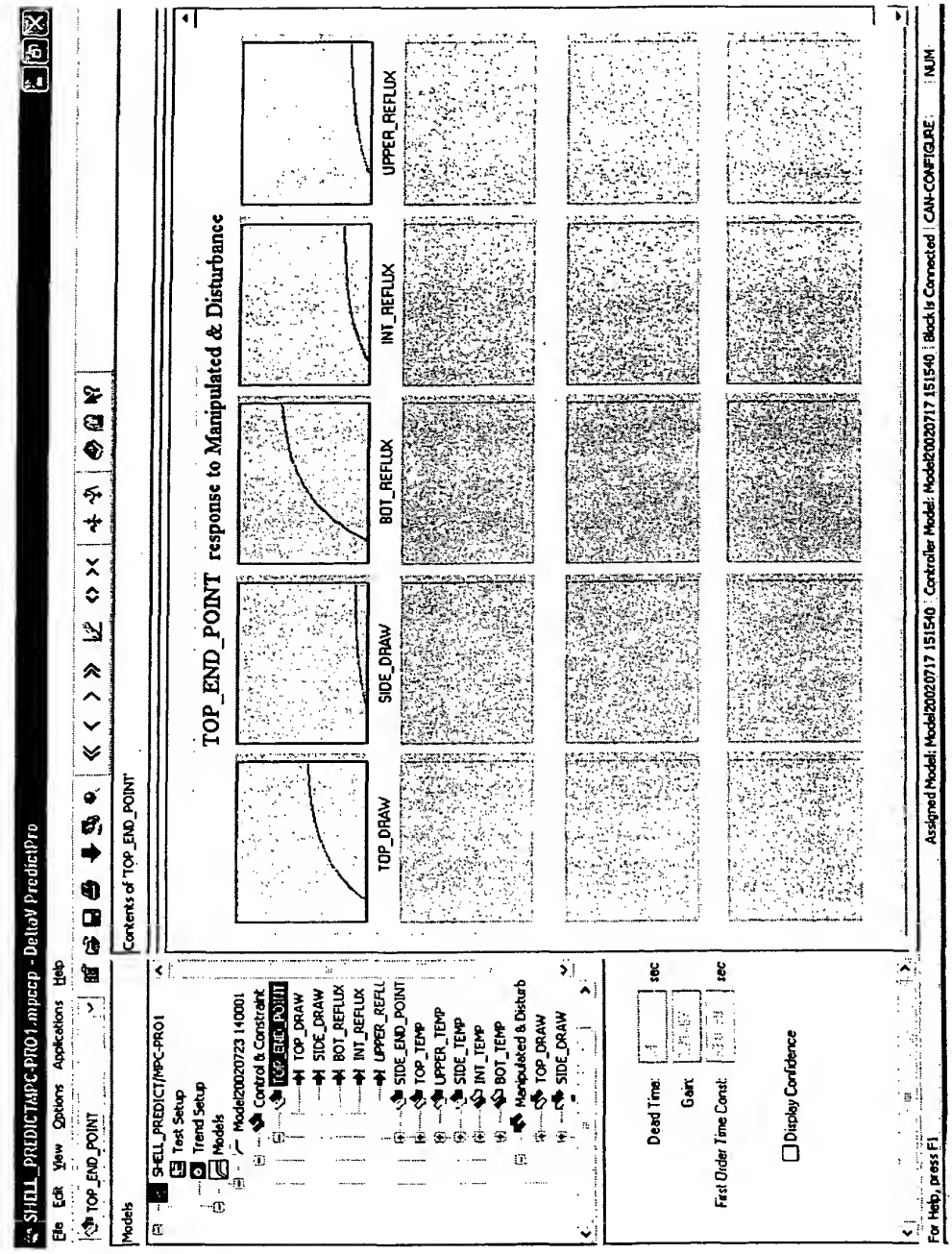

SHELL_PREDICTMPC-PRO1.mpccp - DeltaV PredictPro
File Edit View Options Applications Help
TOP_END_POINT
Models
Contents of 'TOP_END_POINT'
SHELL_PREDICT/MPC-PRO1
Test Setup
Trend Setup
Models
Model20020723 140001
Control & Constraint
TOP_END_POINT
TOP_DRAW
SIDE_DRAW
BOT_REFLUX
INT_REFLUX
UPPER_REFLUX
SIDE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Manipulated & Disturb
TOP_DRAW
SIDE_DRAW
TOP_END_POINT response to Manipulated & Disturbance
TOP_DRAW
SIDE_DRAW
BOT_REFLUX
INT_REFLUX
UPPER_REFLUX
Dead Time:
Gain:
First Order Time Const:
sec
Display Confidence
For Help, press F1
Assigned Model: Model20020717 151540 | Controller Model: Model20020717 151540 | Block is Connected | CAN-CONFIGURE | NUM

FIG. 12

FIG. 13

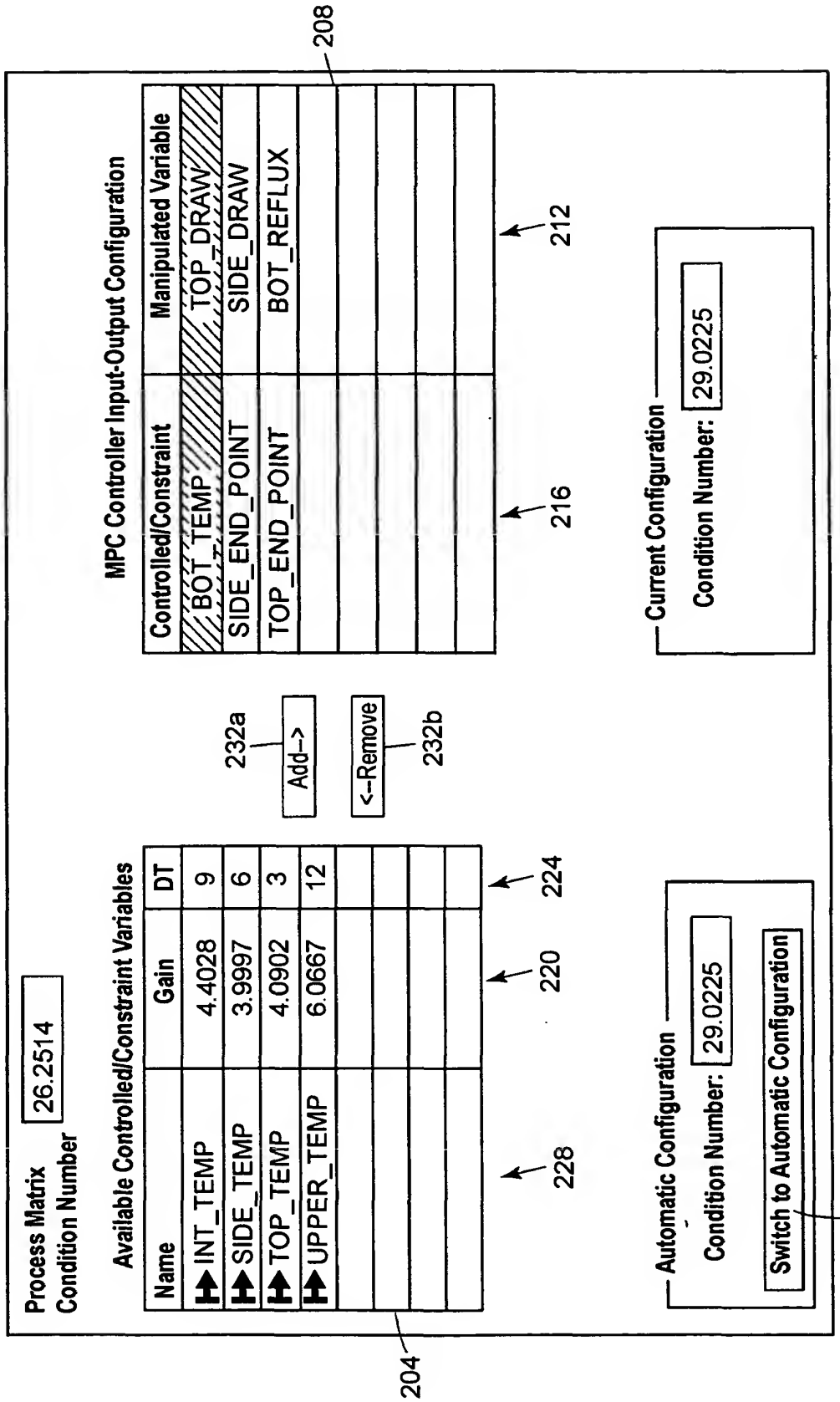
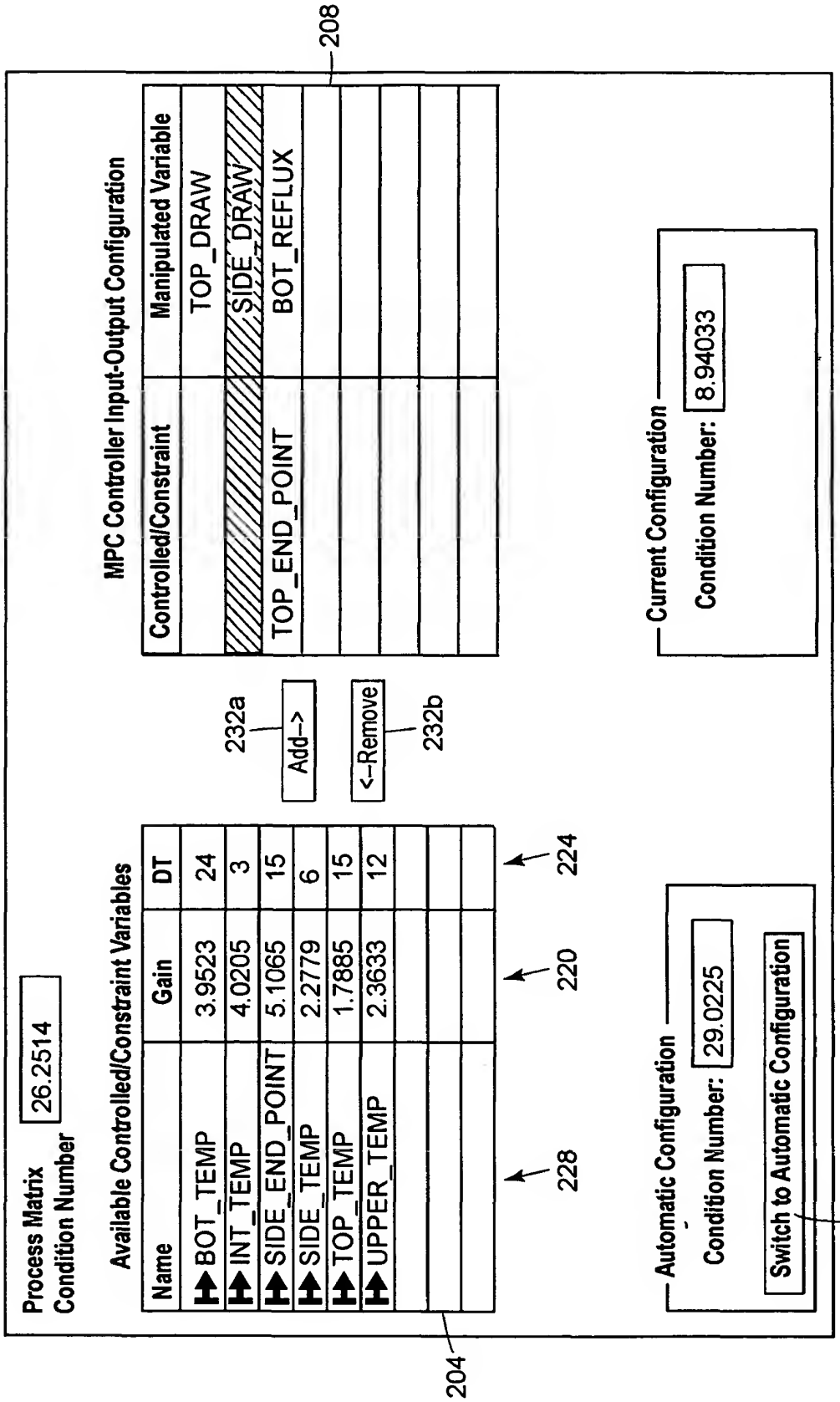

Process Matrix Condition Number
26.2514
Available Controlled/Constraint Variables
Name
Gain
DT
INT_TEMP
4.4028
9
SIDE_TEMP
3.9997
6
TOP_TEMP
4.0902
3
UPPER_TEMP
6.0667
12
Add->
<-Remove
MPC Controller Input-Output Configuration
Controlled/Constraint
Manipulated Variable
BOT_TEMP
TOP_DRAW
SIDE_END_POINT
SIDE_DRAW
TOP_END_POINT
BOT_REFLUX
Automatic Configuration
Condition Number:
29.0225
Switch to Automatic Configuration
Current Configuration
Condition Number:
29.0225
200
204
208
212
216
220
224
228
232a
232b
236

FIG. 14


Process Matrix Condition Number
26.2514
Available Controlled/Constraint Variables
Name
Gain
DT
BOT_TEMP
3.9523
24
INT_TEMP
4.0205
3
SIDE_END_POINT
5.1065
15
SIDE_TEMP
2.2779
6
TOP_TEMP
1.7885
15
UPPER_TEMP
2.3633
12
228
220
224
204
232a
Add->
<-Remove
232b
MPC Controller Input-Output Configuration
Controlled/Constraint
Manipulated Variable
TOP_DRAW
SIDE_DRAW
TOP_END_POINT
BOT_REFLUX
208
Current Configuration
Condition Number: 8.94033
Automatic Configuration
Condition Number: 29.0225
Switch to Automatic Configuration
236
200

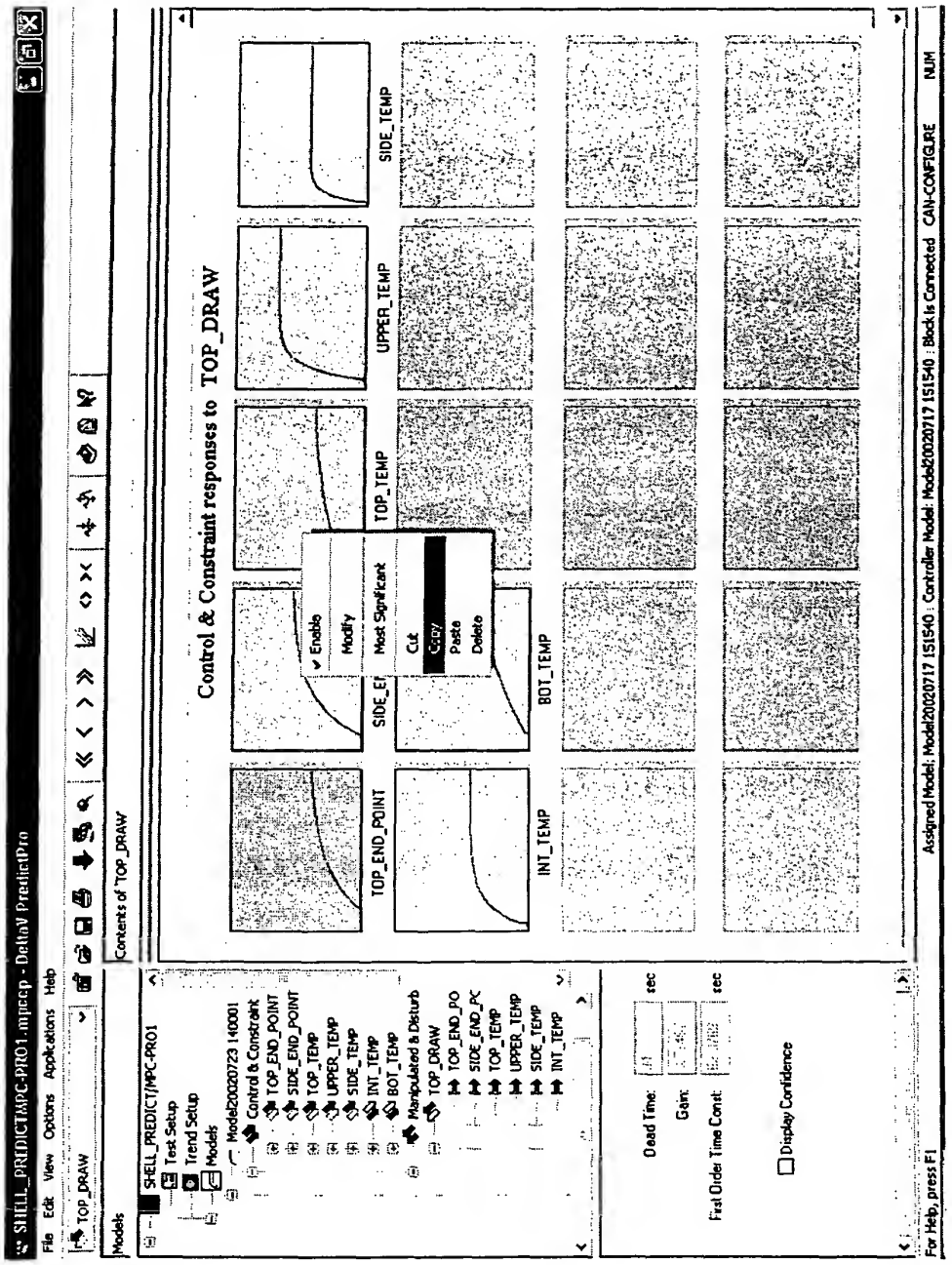

SHELL_PREDICTMPC-PRO1.mpccp - DeltaV PredictPro
File Edit View Options Applications Help
TOP_DRAW
Models
Contents of 'TOP_DRAW'
SHELL_PREDICT/MPC-PRO1
Test Setup
Trend Setup
Models
Model20020723 140001
Control & Constraint
TOP_END_POINT
SIDE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Manipulated & Disturb
TOP_DRAW
TOP_END_PO
SIDE_END_PC
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
Control & Constraint responses to TOP_DRAW
Enable
Modify
Most Significant
Cut
Copy
Paste
Delete
TOP_END_POINT
SIDE_EI
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Dead Time:
Gain:
First Order Time Const:
sec
sec
Display Confidence
For Help, press F1
Assigned Model: Model20020717 151540 : Controller Model: Model20020717 151540 : Block Is Connected
CAN-CONFIGURE
NUM

FIG. 15

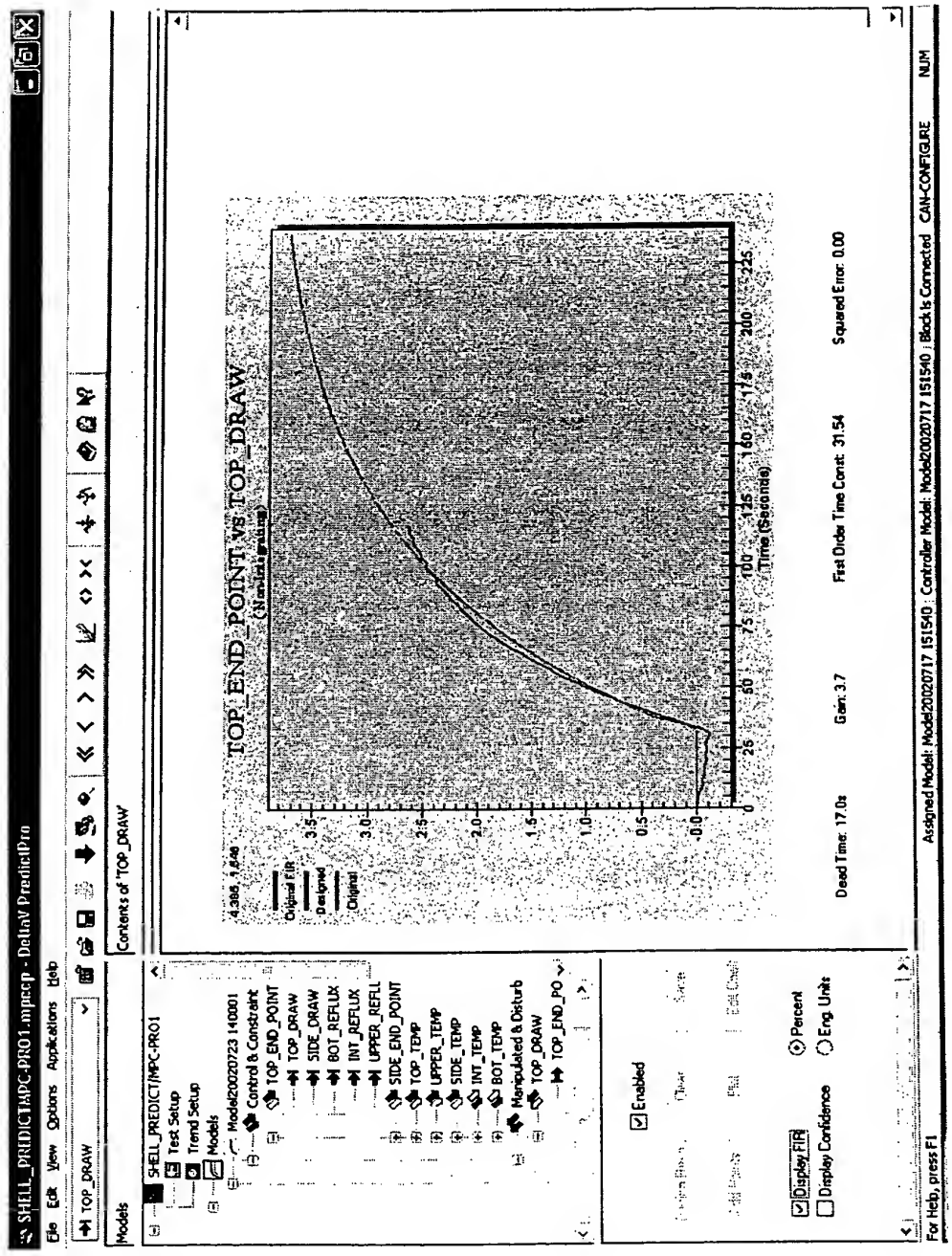

SHELL_PREDICT/APC-PRO1.mpcpj - DeltaV PredictPro
File Edit View Options Applications Help
TOP_DRAW
Models
Contents of 'TOP_DRAW'
SHELL_PREDICT/MPC-PRO1
Test Setup
Trend Setup
Models
Model20020723 140001
Control & Constraint
TOP_END_POINT
TOP_DRAW
SIDE_DRAW
BOT_REFLUX
INT_REFLUX
UPPER_REFL
SIDE_END_POINT
TOP_TEMP
UPPER_TEMP
SIDE_TEMP
INT_TEMP
BOT_TEMP
Manipulated & Disturb
TOP_DRAW
TOP_END_PO
Enabled
Display FIR
Display Confidence
Percent
Eng Units
TOP_END_POINT vs TOP_DRAW
(Nonlinear)
4.386, 1.646
Original FIR
Designed
Original
Time (Seconds)
Dead Time: 17.0s
Gain: 3.7
First Order Time Const: 31.54
Squared Error: 0.00
For Help, press F1
Assigned Model: Model20020717 151540 : Controller Model: Model20020717 151540 : Block Is Connected
CAN-CONFIGURE
NUM

FIG. 16

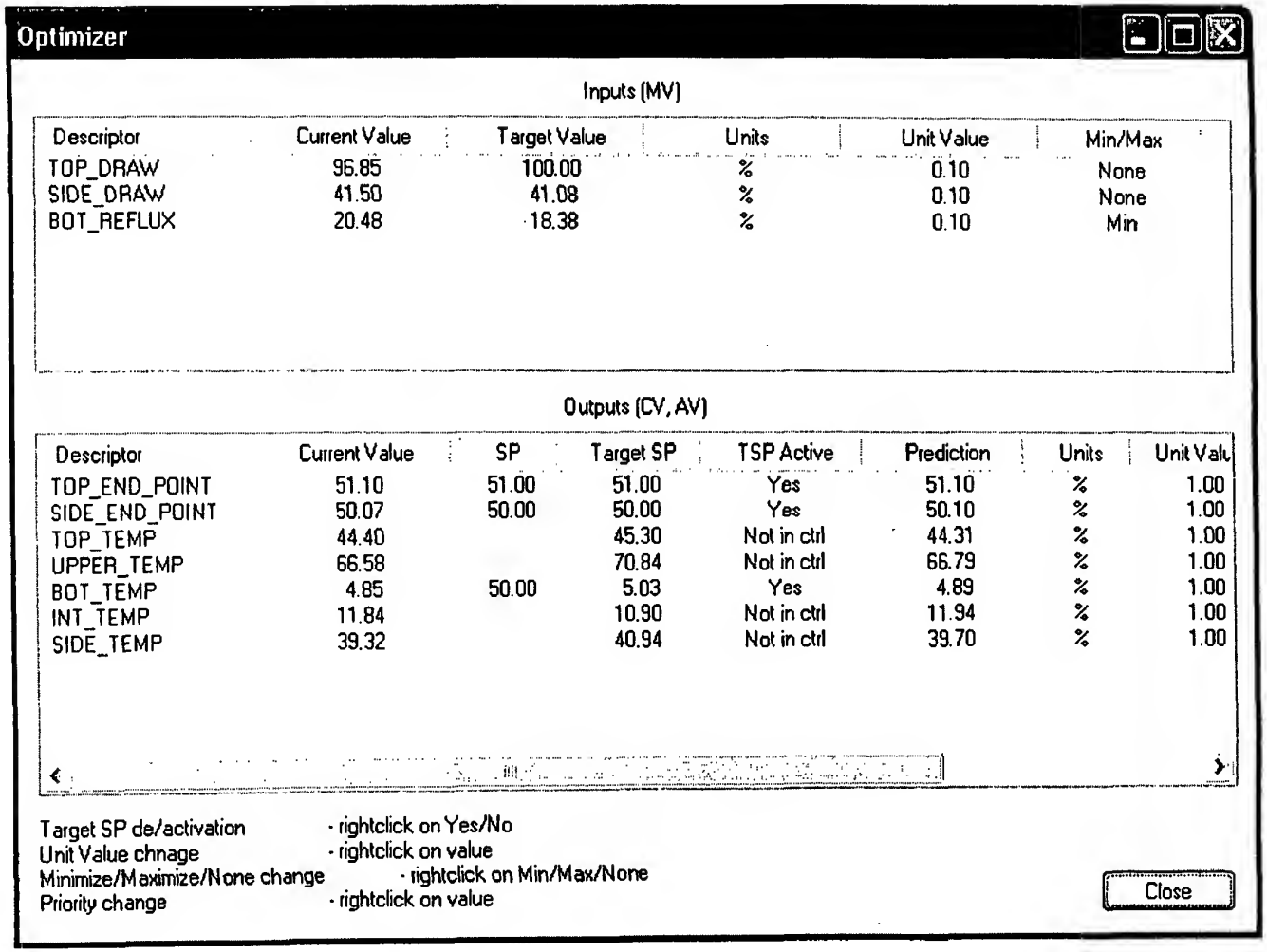


FIG. 17

Applicants: Ashish Mehta, et al.
Atty. Dkt. #: 06005/38043A
Title: Integrated Model Predictive Control....
MARSHALL, GERSTEIN & BORUN (312) 474-6300
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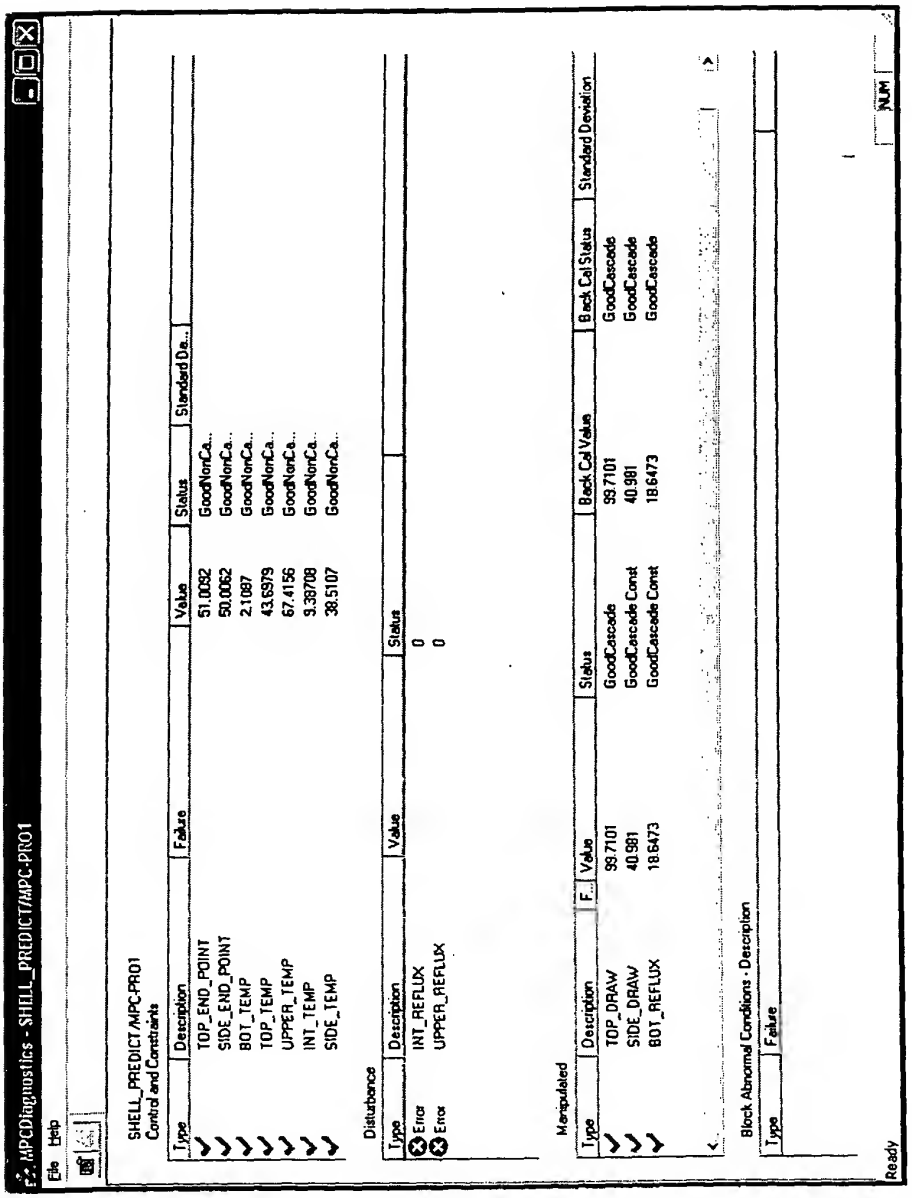
MPCDiagnostics - SHELL_PREDICT/MPC-PRO1
File Help
SHELL_PREDICT/MPC-PRO1
Control and Constraints
Type Description Failure Value Status Standard De...
TOP_END_POINT 51.0092 GoodNonCa...
SIDE_END_POINT 50.0062 GoodNonCa...
BOT_TEMP 2.1087 GoodNonCa...
TOP_TEMP 43.6979 GoodNonCa...
UPPER_TEMP 67.4156 GoodNonCa...
INT_TEMP 9.39708 GoodNonCa...
SIDE_TEMP 38.5107 GoodNonCa...
Disturbance
Type Description Value Status
Error INT_REFLUX 0
Error UPPER_REFLUX 0
Manipulated
Type Description F... Value Status Back Cal Value Back Cal Status Standard Deviation
TOP_DRAW 99.7101 GoodCascade 99.7101 GoodCascade
SIDE_DRAW 40.981 GoodCascade Const 40.981 GoodCascade
BOT_REFLUX 18.6473 GoodCascade Const 18.6473 GoodCascade
Block Abnormal Conditions - Description
Type Failure
Ready
NUM

FIG. 18